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ABSTRACT

A 1986 global survey revealed that mathematics and science are firmly in place in school curricula worldwide, but teaching of technology has a much more tentative hold. All of the countries that responded taught science and mathematics at most levels but technology was taught in only a few countries. In an effort to probe more deeply into the adequacy of science, mathematics, and technology curricula to meet national needs and their appropriateness in relation to the rapidly evolving nature of science and technology themselves, a series of national case studies were undertaken. This first case study was prepared by the Central Institute for Educational Research (CIER) of the People's Republic of China. It covers the teaching of science, mathematics, and technology in primary and secondary schools. It focuses on the following aspects: (1) a review of the present situation in the teaching of these subjects; (2) a consideration of how the curriculum in these fields should meet current social needs in China; (3) an account of reforms that are currently taking place in the teaching of these subjects; and (4) plans for future experiments. Appendices include sections on education and social needs and on mathematics topics found in magazines. (Author/CW)

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Unesco

Science and Technology in School Curricula

Case Study 1
People's Republic of China

Social Needs and
the Teaching of Mathematics,
Science and Technology
in Primary and Secondary Schools

Unesco

ED-87/WS/36

PREFACE

In 1986, Unesco published a global survey on the place occupied by the teaching of science, mathematics and technology in school timetables.[1] The survey revealed that mathematics and science are firmly entrenched in school curricula world-wide, but that the place of technology is much more tentative. In all the 97 countries which responded to the survey questionnaire, mathematics is taught at all school levels and science at most levels. Technology, however, is taught in relatively few countries. The survey also revealed a great diversity of emphasis on mathematics and science, from one country to another, in terms of the time allowance for these subjects.

To probe more deeply into the adequacy of science, mathematics and technology curricula to meet national needs, and their appropriateness in relation to the rapidly-evolving nature of science and technology themselves, a series of national case studies were undertaken. This first case study was prepared by the Research Group for Science Teaching of the Central Institute for Educational Research (CIER) of the People's Republic of China. It covers the teaching of science, mathematics and technology in primary and secondary schools. In particular, it focuses on the following aspects:

1. A review of the present situation in the teaching of these subjects.
2. A consideration of how the curriculum in these fields should meet current social needs in China.
3. An account of reforms that are currently taking place in the teaching of these subjects.
4. Plans for future experiments.

The selection of material and the opinions expressed are those of the authors; they are not necessarily those of Unesco.

1 *The Place of Science and Technology in School Curricula: A Global Survey*. Unesco, 1986.

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Introduction

The task of primary and secondary education in China is to improve the quality of the whole nation, to imbue its socialist citizens with lofty ideals and moral integrity, to educate them well, to teach the value of discipline and to help them to lay the foundations for the training of the many kinds of skilled personnel that modern socialist construction needs. Education is also of great importance in the spreading of scientific and cultural knowledge and in helping students to develop a scientific approach and an attitude which makes for competence and individuality.

The content of primary and secondary curricula should also accord with contemporary developments of social politics, of the economy, and of science and technology. Certain items of knowledge and of skill must be included in elementary education if they are used widely and frequently. If not, such knowledge or skill will atrophy.

The following tables show the current allocations of time given to mathematics, science and technology in primary and secondary schools.

Teaching Programme for Full-time Key Secondary Schools

Subject	Junior Secondary School			Senior Secondary School			Total Class Hours	%
	I	II	III	I	II	III		
Maths	5	6	6	5	5	5	1 026	18.3
Physics		2	3	4	3	4	500	8.9
Chemistry			3	3	3	3	372	6.7
Biology	2	2				2	192	3.4
Physiology & Hygiene			2				64	1.1
Craft work		2 weeks			2 weeks		360	6.4

Teaching Programme for Five-Year Primary Schools

Subject	Grade (h/p.w.)					Total Hours	%
	1	2	3	4	5		
Maths	6	6	6	7	7	1 152	24.8
Natural Science			2	2	2	216	4.7
Craft work				1	1	72	1.8

Mathematics, science and technology are taught as separate subjects in China and text-books compiled by the People's Education Press are used throughout the country. There were in all 93,221 secondary schools in 1985, with 7,411,300 senior secondary school students, 39,648,300 junior secondary school students, and 3,556,900 teachers. The latter included 602,469 teachers of mathematics, 244,875 of physics, 169,655 of chemistry, 91,282 of physiology, hygiene and biology and 4,275 in charge of courses in craft work. Primary schools in the same year numbered 832,300, with 133,702,000 pupils and 6,021,000 teachers.

China is a developing country with a rural population of eight hundred million. Certain requirements are laid down for the standards, quality and number of the trained personnel needed as the rural economy expands. How to adapt the mathematics, science and technology teaching in primary and secondary education to the needs of the vast rural areas is a matter of great importance. In 1985, students of senior secondary schools in rural towns and villages numbered 5,090,000; in junior secondary schools, they numbered 33,673,000 while pupils in primary schools totaled 112,745,000. It can thus be seen that students from rural areas account for the overwhelming majority of the total students in China. Most of them are engaged in agriculture in their neighbourhoods after graduation. Thus, mathematics, science and technology teaching in primary and secondary schools has to meet the needs of rural development.

In preparing this document, the opinions were sought of a number of professional people on the extent to which the teaching of mathematics, science and technology in primary and secondary schools meets the social needs. This was done by questionnaire and informal discussion; newspapers and magazines were also consulted in our investigation. The main objective of our study was to uncover the part of recent graduates working in all trades and professions. In addition, we studied and analysed the frequency of appearance of the teaching content of primary and secondary schools in newspapers and periodicals. This can partly reflect the extent to which education is geared to social needs. Consequently, we consider our findings to be semi-quantified, comparatively exact and comprehensive.

What follows will expound how mathematics, physics, chemistry, biology, physiology and craft work is designed to meet social needs, and analyse the current requirements in this respect. Then we will describe the reforms being made in these subjects. Finally, we shall discuss some integrated experimental plans for the teaching of mathematics, science and technology in primary and secondary schools.

The Present Situation in the Teaching of Mathematics, Science and Technology in Primary and Secondary Schools

In discussing the content of teaching, we have considered both the political and economical needs of society and the students' physical and mental development. We have adhered to the principles of combining theory with practice and teaching with productive labour. To determine the scope and the quality of the teaching, we have considered not only the content, range and the logical order of scientific knowledge, but also the students' abilities of acceptance, their bases of knowledge and their experiences of life. Meantime, we have tried to encourage them to concern themselves to some extent with practical issues in social life.

Since the founding of the People's Republic of China, the People's Education Press has been in charge of the devising and printing of five sets of primary and secondary school teaching programmes and six sets of textbooks. More than one billion copies of textbooks are offered every year and 2.2 billion in recent years. These textbooks are compiled with an emphasis on the teaching of rudimentary knowledge and elementary technical skills. They have played a very important role in fostering the youngsters' education. Nevertheless, we do not think all of them are entirely suited to the country's social and economic development. There are still problems which have yet to be solved. For example, some of the content of the national texts is divorced from the different characteristics of the different areas, nationalities and realities of the country. Science courses lay too much stress on the needs of students entering schools of higher education; some of the content is too difficult and it does not link well with the realities of production and life. The knowledge imparted in different subjects is not well connected or coordinated. This makes for repetition and a failure to re-inforce ideas. For instance, when electron cloud is taught in chemistry in senior secondary grade one, wave motion has not even begun in physics. Such discords need attention.

We will now discuss sequentially the subjects of mathematics, physics, chemistry, biology and physiology in secondary schools, then mathematics and natural science in primary schools as well as craft work generally so as to see how well these curricular elements meet the needs of society.

SECONDARY MATHEMATICS

The Purpose and the Content of Secondary Mathematics

The purpose of mathematics teaching in secondary schools is to enable the students to have a good command of the basic mathematics necessary for the study of modern science and technology, to be quick and accurate in performing mathematical operations, to acquire spatial imagination, and to learn to think logically so that they will be able to analyse and solve problems independently. An enthusiasm for mathematics should be encouraged, and attention should be paid also to the cultivation of a dialectical materialist point of view.

The course content for junior secondary schools includes knowledge of rational numbers, integral expressions, fractional expressions, equations of the first degree, inequalities, systems of first degree equations, straight line figures, radicals and exponents, quadratic equations, common logarithms (so as to prepare the students for logarithmic computation in the future), the solution of triangles, circles, direct proportion, inverse proportion, linear functions, quadratic functions (and their respective graphs), equations of straight lines and of circles. The junior secondary school mathematics course concludes with an introduction to plan and elevation and to statistics, both of which are widely used today.

The course content for senior secondary schools begins with the concept of function as a mapping of one set upon another. It continues with power functions, the exponential function, the logarithmic function, trigonometric functions and inverse trigonometric functions. These are followed by an introduction to solid figures, the study of quadratic curves, polar co-ordinates and the use of parametric equations in co-ordinating geometry. The course continues with systems of linear equations, the properties of inequalities (and their proofs), complex numbers, permutations, combinations, the binomial theorem, probability, the algebra of logic (as used in computers) and an introduction to calculus.

How Secondary Mathematics Meets Social Needs

Two procedures were used in order to investigate how far secondary mathematics meets social needs. One involved sounding opinion by questionnaire and holding informal discussions in six different areas of the country. Altogether 20 discussions were held (with some 180 people present), and 280 questionnaires were sent out, of which 260 were returned. The other procedure involved scanning the mathematical content of 76 kinds (6 fields) of magazines (published from January to June, 1985). The magazines selected for scanning were middle level and typical of China. The outcome of these investigations are set out in Appendices I and II.

The Analysis of the Investigations

Appendices I and II show in a semi-quantified way how well secondary mathematics is judged to meet the needs of the social political and economic development of China. From these the following conclusions may be drawn:

- The conception and operation of rational numbers, algebraic expressions, the solution of equations, the concept of a function in algebra, the idea of proportion and drawing skill in plane geometry are all needed in almost every special field and the teaching of these topics should be strengthened;
- Items which are less needed in all but a few special fields include radicals of higher degree, simple systems of quadratic equations with two variables and their solutions, systems of first degree inequalities in one variable and the solution of them, the basic knowledge and application of homothetic figures, the principle of orthogonal projection, and the technique of drawing the plan and elevation of simple solids. Consequently, the content of these topics should be simplified of used only as supplementary material;
- Content which reflects the development of science, technology and production should be increased. In particular, electronic computers, especially BASIC language, the electronic calculator, initial knowledge of the different calculus, probability and statistics are all essential in the development of science, technology and production. These topics should be strengthened.

A Brief Summary

The content of secondary mathematics teaching does in a fundamental way measure up to the needs of society. School leavers fall roughly into three categories. Most of them will participate directly in productive industry and agriculture. Some of them will enter a vocational or polytechnic school. Yet others will go on to education of a higher level. Consideration should therefore be given to the needs of these three categories in the secondary school. Those students who may participate directly in productive labour after graduation should learn more basic knowledge of mathematics so that they can fit themselves for their future work. They do not need so much theory since they will be asked to *use* the knowledge in practical tasks. Those who may enter a vocational school after graduation to prepare themselves for special tasks in the future should follow the principle of utility. For them, the teaching content should be 'extensive and easy'. Those who may go on to higher education after graduation may need more mathematical knowledge. For this reason, mathematics textbooks for such students are being compiled.

Thus, in order to meet the general needs of society, the content of secondary mathematics should be 'extensive and easy'. Meanwhile, some special content and selective courses should be arranged in order to cater for the social needs of different fields of future employment.

SECONDARY PHYSICS

Its purpose and content

The purpose of physics teaching in secondary schools is to enable students to grasp systematically the basic knowledge of physics needed for the further study of modern science and technology and to understand its application in practice. In addition, it should help them to acquire experiment skills, develop the ability to think and to use mathematics to solve physics problems, cultivate a dialectical materialist viewpoint, and make them aware of the need to study hard and to struggle for the modernization along socialist lines of industry, agriculture, national defence and of science and technology in our country.

The content of junior secondary physics includes measurement, motion and force, density, pressure, buoyancy, simple machines, work, energy, elementary optics, heat, expansion due to heat, thermal conductivity, the change of state of matter, the thermal motion of molecules, thermal energy, heat engines, simple phenomena of electricity, the laws of electric current, electrical work, electrical power, electromagnetic phenomena, and a general knowledge of the uses of electricity.

The content of senior secondary physics includes force, the equilibrium of bodies, rectilinear motion, orce and motion, the interaction of bodies, curvilinear motion, universal gravitation, mechanical energy, vibrations and waves, molecular motion theory, heat and work, properties of a gas, a liquid and a solid, electromagnetic induction, alternating current, electromagnetic oscillation, electromagnetic waves, the foundations of electronic technology, the reflection and refraction of light, atoms and atomic nucleus.

How Far Secondary Physics Meets the Needs of Society

We chose to question 550 people in 9 fields of 13 provinces or cities as a means to investigating the social needs of secondary physics. All of them returned our questionnaires. Opinion was sought mainly on those items which have been in dispute in compiling physics textbooks. The detailed results of the investigation are set out in Appendix III.

The Analysis of the Results of Investigation

Because opinion was sought on disputed topics, the outcomes indicate how far secondary physics teaching is meeting the diverse needs of society. Our belief is that a certain core of content is needed in most occupations, though, evidently, the importance of particular items varies from occupation to occupation. We conclude as follows:

- The topics which most areas of employment use and therefore need to be taught are significant figures, composition and decomposition of forces, mechanical drive, the connection of capacitors in series and in parallel, the concept of electromotance and the use of universal meter, the power factor, triphase alternating current and transformer. But the measure of necessity is about 2.0 on a scale which ranges from 0.0 to 3.0; this suggests that the content should aim at qualitative understanding in physics teaching;
- Less needed topics include the calculation of simple periodic motion, simple pendulum, stationary wave, Doppler effect, ultrasonics, geomagnetic field, Lorentz force, cyclotron, mass spectrometer, the imagery of plane mirror and curved mirror, composed lens and the structure of the eye, the structure, principle and use of an epidiascope and telescope, laser beam, holograph, polarization, special relativity, an elementary introduction to quantum theory and solid-state theory, and radioactive pollution. But it should be noted that some of these topics reflect achievements and theories in modern science and technology which have not been extensively exploited in our economic construction. This may reflect our relatively low level of economic development. Since these topics can broaden the students' vision and foster their scientific approach and attitudes to science, they should be offered as elective subjects or as extracurricular material;
- In the course of our investigation, several symposiums were conducted. At these, certain shortcomings of content were disclosed. For example, the windlass is very commonly used in north China, but less so in the south. Again, the qualification of some content is sometimes more difficult than its quantification. For instance, the law of lense imaging can seldom be grasped by students by observing a single experiment, but it becomes easier if the students can visualize the path of a beam of light. Some items of content are divorced from mathematics teaching. For example, the conception of vector used in physics is not included in mathematics, nor is that of positive and negative index. These problems need attention.

A Brief Conclusion

The current physics course is very systematic, but is not in close harmony with real life and industrial production. Society needs the teaching to give students a qualitative command of the fundamental conceptions and laws of physics. Complicated calculations in the physics course should be avoided. Effort is needed to broaden the scope of knowledge and relate it to its practical uses.

SECONDARY CHEMISTRY

The Purpose and Content of Secondary Chemistry

The purpose is to enable the students to grasp firmly and systematically the basic knowledge of chemistry, to learn some elementary skills, to train and develop their capacities, and to cultivate their dialectical materialist and patriotic viewpoint.

In junior middle school, chemistry starts with a study of common things like air and water. Then carbon, a very common element, is introduced and also an important and common system of dispersal, namely solutio[illegible]. Eventually, the course concludes with the concepts of acids, bases and salts, the nature of an oxide and their rules of reaction.

In senior middle schools, the structure of matter and the periodic table are introduced, based on the study of sulphur and alkalimetals. These ideas lead on to nitrogen and phosphorus. Other concepts are introduced such as speed of reaction, chemical equilibrium, electrolysis, and the elements silicon and magnesium. Organic materials appear when the oil industry and macromolecular compounds are simply explained.

How Far Secondary Chemistry Meets Social Needs

This investigation involved 12 fields in 6 provinces. Sixteen discussion meetings brought together 165 people, and 464 questionnaires out of 510 sent out were returned. The occupations represented in the survey were made up of the machinery and electric industry (21 per cent), communications (9.6 per cent), textiles (11 per cent), light industries (21 per cent), chemical industries (8.4 per cent), metallurgy (3.7 per cent) architecture (2.6 per cent), apparatus manufacture (7.3 per cent), education (8.5 per cent), civil services (3.7 per cent), military industries (2.4 per cent), and other fields (11.1 per cent). The statistics of the findings are set out in Appendices IV and V.

The Analysis of the Investigation

The opinions expressed were divided as between those from rural and from urban areas. With chemistry it is helpful to try to understand the different needs of rural and urban occupations. The findings were as follows:

- In *urban* areas, the topics most needed are the concepts of atoms, molecules and elements, symbols for the elements, solutions, percentage concentration, acid, base, air, water, the use of ordinary chemical instruments, and the identification of matter. These are the substance of basic chemical theoretical knowledge. They have wide application in all trades and professions;
- Less in demand are the law of conservation of mass, ionic compound, covalent compound, oxidation-reduction reactions, and chemical fertilizer. In discussion it was pointed out that electronic formulae, solution equilibrium, the calculation of complex degrees of solution, the configuration of the electron shells of the elements such as calcium and other topics involve complex calculations and these should be reduced;
- In *rural* areas, the topics most needed are solutions, percentage concentration, oxidation, air, water, acid, chemical fertilizer, calculation according to chemical formulae, calculation of solubility, and the preparation of solutions;
- Less needed are atom, element, oxidizing and reducing agents, C, CO, CO_2, ionic compound, covalent compound, and the use of ordinary chemical instruments. This reflects a lower level of economic development in the countryside. In discussion the need was emphasized for chemical fertilizers, agricultural insecticides, energy sources, and pollution.

A Brief Conclusion

The schools place an emphasis upon basic knowledge, especially the fundamental concepts and principles. The order of the content stresses a logical arrangement. There is a tendency to neglect the practical needs of students. Those who will become labourers in industry and in agriculture need a command of the basic knowledge of elements and compounds and some practical skills in working with them.

Indeed, the findings in both urban and rural areas show that more practical knowledge is needed. While urban areas seem to need more chemical knowledge than rural ones, some topics are less important for urban areas than rural ones (e.g. chemical fertilizers, agricultural pesticides). The solution to this

divergence is to adopt a single syllabus but to provide a variety of teaching materials or to offer elective courses.

SECONDARY BIOLOGY AND PHYSIOLOGICAL HYGIENE

The Purpose and Content of Secondary Biology and of Physiological Hygiene

The purpose of secondary biology has three aspects: those of knowledge, method and attitude. The aims are to impart basic knowledge and skills, to help students to understand biological phenomena and the fundamental concepts and laws associated with them, to foster the students' practical skills and to strengthen their ability to analyse and to discriminate between the basic structure of organisms and their functions. The students are asked to observe carefully, to make hypotheses and to test them. The students will also learn something more about dialectical materialism and patriotism and appreciate the contributions of biology to the benefit of human beings.

The purpose of physiological hygiene is to impart basic knowledge of the structure of the human body and its functions, to teach hygiene and the means to good health.

In junior secondary school, the course in biology covers green and flowering plants, the categories of plants and the plant community. Nine experiments are included. The study of green and flowering plants systematically explains the basic theories of plant morphology, physiology and physio-taxonomy. It includes observation and practical knowledge of anatomy. Categories of plants touch on the basic theories of pteridophyta, vaterial plants, tundra, lichens, seed plants, their features, life histories, morphological structure, environment, their relations with human beings and the plant kingdom. The examples of community include communities of water plants and of forest plants. The geographical distribution of plant communities in China is explained as are sources of rare plants and their protection. The nine experiments are fundamentally associated with teaching.

The first sequence in zoology covers phyla, protozoa, coelententerate, verne, nematode, mollusc, arthroped, enchinoderm, chordata. The second sequence includes zoological evolution and geographical distribution in China. The course ends with a summary of evolution and an introduction to ecology.

Biology in senior middle school covers cells, biological metabolism, biological reproduction and development, regulation of life, genetics and hereditary change, life origin and evolution of life, biology and environment and other experiments.

The physiology course covers the human body, skin, systems of activity, the circulatory system, the respiratory system, the digestive system, metabolism, the excretory system, the nervous system, reproduction and development, infectious diseases and ten experiments. Simple observation and examination are stressed, and students learn to measure vital capacity and chest circumference, to test eyesight and blind spot.

How Far Do Biology and Physiological Hygiene Meet the Needs of Society

The investigation covered a variety of fields in 4 provinces and cities. Opinions were sought of 240 young workers, staff members and peasants. Four discussion meetings were held with 5 to 10 people in each. The findings of questionnaires are set out in Appendix VI.

A study was also undertaken of biological references made in 12 newspapers with large cirulations and in 38 types of magazine. Fifty magazines and newspapers carried essays on biological shape, physiological classification, heredity, evolution, and ecology. These numbered 2,724 in all. This reflects the interest in biology of society as a whole.

The Analysis of the Investigation

A number of conclusions follow from an analysis of the investigation. These are:

- The biological content that is most needed by society includes the structure of plants - cells, tissues, organs and root, stem, leaf, flower, fruit and seed;
- The zoological content needed includes plasmodium, jellyfish and coral in coelenterate, tapeworm and blood fluke in protozoa, roundworm and hook worm in nematoda, leech and earthworm in annelida, every kind of economically useful shellfish in molluscs, etc., as well as fishes, birds, mammals and resources protection that are related to the life of human beings;
- The content of senior secondary biology most needed include the prevention of hereditary disease, the application of principles of heredity and variation in breeding, ecological balance and the protection of the

natural environment, the application of animal hormone in the production and the structure of the human body, health protection and knowledge of physiological hygiene. All the content listed above should be retained and enhanced;

- Less important are parts of form in botany, algae and fern in classification, the geographical distribution of plant association, vertebrates in zoology, digestion, circulation, excretion, and reproduction. The requirements of these topics should be greatly reduced or classified as supplementary reading.

Combining the views expressed in discussion with the findings of the investigation of magazines and newspapers, it would seem necessary to augment the treatment of edible bacteria, breeding, asexual hydridization of fruit trees, knowledge of flowers and plants, cancer, heredity, use of the electron microscope, preservation of the natural environment, ecology, poultry rearing, and sexual reproduction. In general, it is clear that the content of the biology and hystology teaching is sound in its systematic integrity, but it would seem that the descriptive work tends to occupy too much of the content at the expense of theory and practice. This situation should be adjusted. For example, we can increase the treatment of ecology, cultivation, poultry, etc., while physiological hygiene should include such topics as health, medical treatment, nutrition, and health care. Also, because of the earlier onset of puberty in youth, it would seem preferable to offer the course in physiological hygiene during the first grade of the junior secondary school.

PRIMARY MATHEMATICS

The Purpose and Content of Primary Mathematics

The purpose of primary mathematics is to enable the students to understand and to grasp a basic knowledge of numerical relationships and of geometric figures. They should learn to perform the four fundamental operations with integers, decimals and fractions correctly and rapidly. The teaching should cultivate an elementary ability to think logically, cultivate a sense of space, and an ability to use the knowledge acquired to solve simple problems in daily life. Meanwhile, the students will receive education in ethics through the content of the teaching.

The content of primary mathematics includes, mainly, the four fundamental operations of arithmetic with integers, fractions and decimals, the calculation of the area of geometric patterns, the calculation of volumes, statistical drawing, calculation with an abacus, percentage, proportion, and problems solving via equations.

How Far Does Mathematics in Primary School Meet Social Needs

The teaching content is practically the same in both the primary school of the five-year system and that of the six-year system. We chose three provinces or cities to investigate by questionnaire the social needs of primary mathematics. The method adopted was to find out how much of the primary curriculum those questioned could remember, the hypothesis being that knowledge used is knowledge remembered and this can be regarded as a measure of the items needed in society and in the economy. As well as questioning individuals, ten forums were held twenty-one times, involving nearly 200 participants. The results of the investigation are set out in Appendix VII.

The Analysis of the Investigation

As can be seen, the items most frequently forgotten are calculating the area of a circle and of a sector, calculating the volume of a cuboid and of a cone, and drawing geometrical figures from given measurements. This suggests that these skills are not used extensively in daily life and work and casts doubt upon the need to teach them. For instance, it may be enough that the students understand how to draw a figure without actually having to do so. In the early teaching of geometry, the emphasis should be on form and structure;
The main finding of the forums was that it is important to raise the level of ability to solve practical problems by increasing their difficulty and assisting children to think through a given problem. It was believed that simple proportion should be taught in secondary school. It was noted that calculation with an abacus is neglected because it is not examined on transfer to a higher school or grade. Performance, however, is better in schools which use the 'THREE DO COMBINATION' (performing a calculation on the abacus and also in the head while chanting aloud the result), a method which began in the late 1960s and which was thought highly of by visiting Japanese and American specialists.

A Brief Summary

Mathematics in primary school mainly involves number relationships and spatial awareness. Its content has extensive applications, so does a knowledge of geometrical figures. These aspects not only lay a foundation for the further study of mathematics, but they also offer tools for the study of science and technology. therefore, the content of mathematics in primary school is of the utmost importance.

PRIMARY SCIENCE

The Purpose and Content of Primary Science

The purpose of primary science is to help children to take their first steps towards knowing the natural world and its exploration, utilization, reformation and protection by human beings. It should raise their interest in science, in studying science, and in using science. It should foster a delight in nature, a scientific attitude, a love for their home town and for the socialist motherland. Finally, it should improve their health both physically and mentally.

The teaching content of natural science includes imparting knowledge about the four seasons, water, air, the globe, the solar system, space, plants, animals, machines, power, energy and matter.

The Social Needs of Primary Science

We chose about 320 people in 5 provinces or cities to investigate the social need for primary science. We received 121 questionnaires and held 16 forums, involving about 200 people. The results of the investigation are set out in Appendix VIII.

The Analysis of the Results of the Investigation

Taking together the returns of questionnaires and the information gathered in the forums public opinion would indicate that the following are the basic items of content which are largely needed in society:

- The four seasons, change of temperature, the three states of water, the relationship between water and human beings, man's struggle against flood, the use of steam power, the pollution and protection of water, wind, the composition of air, the pollution and protection of air, mineral products, soil and its protection, the phases of the moon, solar eclipse, the revolution of the earth, the sun, movements of the human body, simple machines, types of energy and the nature of matter;
- Items that are less needed include the reason for changes of temperature, the principles of sinking and buoyancy, the geological effects of water, different kinds of rock, and the constellations.

A Brief Summary

Most of the teaching content of primary science is needed by society. Science in primary school is an important basic subject. Children need an enlightened education in science and its study will influence them very deeply all their lives. Nowadays, the teaching content aims to increase the knowledge of students and to sharpen their intelligence. But some topics are of doubtful value for young children. These include, for example, discrimination between rock formations, feeding silkworms (impossible in a city), and the appearance of the starry sky in each of the four seasons. These items should be adjusted, deleted, or considered as supplementary.

CRAFT WORK

The Aims of Craft Work

Craft work is a major element in primary and middle school education. Its aims are to enable students to master the fundamental knowledge and techniques of simple labour, to develop a certain ability with their hands, to help them to use their hands and their heads together, to train them to appreciate the value of labour and habits of labour, appreciate the role of labour in public welfare and so train them that they will become capable persons with high ideals and morality, cultured and disciplined in the construction of a socialist state.

The Content of Craft Work

Education in craft work includes some of the fundamental skills needed in industry, in agriculture and in the public service. They generally include those common skills that can be used extensively. The state does not lay down unified requirements. The particular teaching content will be determined in accordance with local needs, the school's conditions, and the students' wishes. The time given to craft work can be spread, as in other subjects, or given in concentrated periods.

The Present Situation

During the course, the students are able not only to apply themselves to real tasks, but also to learn the productive skills that will be used in the future. They can also earn since it has been proved that the essential conditions for a successful craft course are the establishment of a school-run factory, farm or practice garden.

In China, most schools have established such a course; the students learn a lot from it; they improve their skills and achieve good results. But a few schools have not established a course because of their educational philosophy or their conditions. In the light of this, local education committees are seeking to solve the inherent problems.

Some Conclusions

At the present time, China proceeds with its socialist construction along modern lines. Science and technology are the keys to the future and education is the base. China's educational system should train persons to become capable at different levels so as to satisfy the needs of the drive towards modernization. In this sense, it is necessary so to select the content of the mathematics, science and technology, that it will fuel the drive towards modernization. From the analysis of the social needs of the seven courses in China's primary and middle schools, the following inferences may be drawn:

- The teaching of mathematics, science, and technology (in primary and middle schools) should essentially seek to satisfy the needs of society;
- There is a tendency to neglect practical appreciations while stressing theoretical knowledge;
- China is a big country with many minorities and local differences. The present teaching content emphasizes mainly general knowledge. it does not sufficiently take into account local differences;
- At present the teaching pays more attention to the development of groups of students and insufficient attention to the development of individual students.

How Curricula in Science, Mathematics and Technology Should Seek to Meet the Current Social Needs

There would seem to be two major issues: one of principles, one of measures.

Principles

Reorient educational thinking and gear education to every student

In China's primary and secondary schools, the teaching has tended to concentrate on a minority of able students, particularly those who appear to be destined for higher education. In this respect it is necessary to adjust perspectives and gear education first of all to every student.

Harmonize the objectives with the goals of education

The educational aim of China's primary and secondary schools is to help youngsters to develop harmoniously their morality, their intelligence and physique, to lay a foundation upon which the quality of life can be raised and to foster the growth of socialist constructors who will be well-educated, well disciplined possessing lofty ideals and moral integrity. So the reform of the teaching of mathematics, science and technology must be made with this general aim in view, systematically considering the relationships between the subjects in deciding their respective teaching objectives.

Decide teaching materials according to practice

Bearing in mind the fact that the majority of school leavers will enter employment, the teaching should be directed mainly towards the needs of students in their social milieu as agricultural or industrial workers, keeping in mind their likely needs for science and technology subsequently. On the other hand, some variety of approach is called for because of the differences among districts, the imbalance in economic development and cultural foundations between rural and urban areas, the different nationalitites and natural resources.

Distinguish the important from the unimportant and concentrate upon the former

In China, eighty per cent of the population live in rural areas. The structure of agriculture has greatly changed in recent years, particularly since the effective reform of the rural economic system. At the same time, a rapid development of town-owned enterprises has taken place and new technologies have sprung up. Thus requirements are changing. Consequently, the reforms of the teaching of mathematics, science and technology in rural primary and secondary schools which are now taking place are of great significance.

Measures

Required subjects

In the teaching of each science subject, some practical materials related to the various theories in textbooks can be selected to supplement the learning. This would benefit students not only in helping them to apply theoretical knowledge, but also by deepening their understanding of abstract theory and fostering their ability to analyse and solve problems. It would likewise stimulate students' interest in learning and encourage investigation.

Selective subjects

These can usefully impart knowledge and skill needed by society. In most schools, students are allowed to choose according to their interest and personal need from among the following: photography, electricity in the home, accountancy, gardening, household electrical appliances, and needlework.

Out-of-class activities

Another important measure is to organize various out-of-class activities specifically related to practical topics. Out-of-class activities may be reports of special investigations, demonstration of scientific experiments, social investigations, counselling, organizing a science seminar, etc., such activities should be related to social life, or to industrial and agricultural production. The choice of activity should be closely related to what is learned by students in the classroom.

The measures proposed above for the development of required subjects, selective subjects and out-of-class activities can only be regarded as palliatives. The teaching of mathematics, science and technology in primary and secondary school, as a system, need a thorough overhaul and reform should as far as possible take into account the findings brought to light by the several investigations of social needs.

Current Reforms in the Teaching of Science, Mathematics and Technology

In 1981, the Ministry of Education (now the State Commission of Education) drafted 'The Plan and Syllabus of Primary and Secondary Schools'. Subsequently it was modified several times. According to the Plan and Syllabus, the People's Education Press developed and published textbooks on every subject for national use. The requirements of the Syllabus and of the textbooks are comparatively difficult. They emphasized the needs of students who will enter higher grades, but they neglect the social needs. As the reforms of rural and urban economic systems are being brought into effect, society has changed greatly and so have the requirements for graduation. This makes new demands upon the teaching of mathematics, science and technology. Although much revision of the syllabus has taken place many problems still need to be solved. For this reason, many educational research units and many primary and secondary schools have been conducting experiments in the teaching of mathematics, science and technology. The aim of these is mainly to ensure that the teaching materials satisfy social needs and that the knowledge learnt by students will be useful in society after their graduation.

Mathematics

Since the main task of primary and secondary schools is to provide qualified students for higher schools, and because many schools are seeking to raise their rates of promotion, comprehensive experiments in mathematics teaching materials have not yet been carried out. But as the majority of junior secondary students will leave to take part directly in industrial production or in agriculture, some reforms of the teaching materials have been tried in junior secondary schools.

Example

The reform of the economic system in rural areas needs student leavers to possess some basic skills in accountancy. With this in mind, the Sihecheng Secondary School in Zhangwu County, Liaoning Province, has modified the mathematical teaching materials of junior secondary school after discussion with local farmers. The changes include adding with an abacus in grade one, including basic measurement in grades two and three, introducing the principles of the calculator in grade four, and augmenting the teaching time by 102 class hours.

Secondary School Physics

As living standards are raised especially with the expanding use of electricity, it is not enough for a student to learn a little about the uses of electricity. He or she must learn some specific techniques such as: installing a lighting circuit, how to mend particular household electrical appliances such as radio and TV sets and tape recorders. Current reforms of physics mainly involve adding materials to the unified textbooks to meet these particular needs.

Example one

In order to enable students to install an electric light circuit, and to learn about the safe uses of electricity in rural areas, Sihecheng Secondary School in Zhangwu County, Liaoning Province, introduced an additional 34 class hours of teaching in grade four of junior secondary school, systematically training students in the relevant knowledge and skills. Topics included: the production of electricity, the characteristics of various electrical materials, the loss of voltage, causes of and repairs to short circuits, common electrical metres, in-door and out-door transmission lines, general lighting facilities and common disorders of lighting circuits. The school developed its own textbook, used a 'teach and practice' method of instruction, and paid particular

Through this study and practice, many students who were not previously interested in physics became so and were soon actively using physical knowledge in daily life. Some of them made some useful small inventions and became the electrical technicians of their villages. Their skills were greatly welcomed by the adults in the villages.

Example two

The variety of household electrical appliances in urban areas is constantly increasing, but the repairing service is often insufficient in many of them. In response to local need, Harbin No. 6 Secondary School in Harbin, Heilongjiang Province, set up a repair shop for household electrical appliances. It was manned by students who worked under the guidance of teachers. As they studied the principles of the appliances, the students learned to solve the problems of repair and to provide other services, such as counselling on the use of appliances. The shop not only caters for local residents, but also attracts custom from further afield.

The service has greatly stimulated the students' interest in physics and improved their scores.

Secondary School Chemistry

Secondary school chemistry is taught systematically and sequentially. It is knowledge of the elements and their compounds that is related most closely with social needs. As well as this teaching, many schools organize out-of-class activities to meet local needs. Some urban schools are actually producing chemicals and providing a daily service. Some rural schools organized practical advice on the use of fertilizers and pesticides.

Example one

In order to meet the needs for chemicals of rural town-owned and individual-owned enterprises, Suzhou secondary schools in Jiangsu Province set up, as out-of-class activities, various groups, such as the petro-group, the re-use of 'three waste substances' group, and others. According to the local needs for chemicals, the teachers directed students to relevant documents, to search for information and to carry out experiments. Chemical products that have been produced in recent years include: water of high purity, butan, large chalcanthite crystals, etc. In addition to these activities, the school often took students to visit chemical plants, encouraged investigations, writing reports and giving lectures.

The out-of-class activities have greatly strengthened the students' interest in chemistry; they have, in particular, raised the students' operational skills and reinforced their theoretical knowledge. some essays written by students are valuable. Noteworthy examples include 'The Preparation of Large Chalcanthite Crystals', 'The Preparation of Sulphuric Oxide Crystals', 'Investigations of Some Resources in Suzhou' and 'An Introductory Approach to the Recovery and Processing of Several Waste Liquids used in the Laboratory'. In the city's essay contest, these came in for special praise.

Example two

Pesticides and fertilizers are two of the groups of chemicals which are most often used in rural areas. However, many farmers know little about using them properly. Crops often wither and turn yellow as well as die because of improper usage. In order to ensure that graduates become skilled in the use of pesticides and fertilizers, Sihecheng in Zhangwu County, Liaoning Province, added 34 class hours to the normal junior secondary chemical course. They trained students in the correct use of pesticides and fertilizers by teaching the chemical and physical characteristics of the main constituents, identification, transport, storage, key points of use and proper practice, so developing the students' ability to use chemical theories to solve practical problems.

As a result of this course, students have become adept at correct usage and are able to counsel local farmers. Some of them have become the agricultural technicians of their villages.

Secondary School Biology

Affected as it is by the entrance examination for higher education, secondary school biology has not been given the status it deserves for a long time. Though the importance of biology has been realized in recent years, its reform has languished. Current efforts to reform the content focus on out-of-class activities and efforts to combine the teaching content with social needs. So, veterinarian and rearing knowledge has been

added to the teaching on animals, and knowledge of the cultivation of fruit trees and flowers has been added to the teaching on plants.

Example

Huairou No. 1 Secondary School in Beijing has organized activities in forestry to meet the local needs for building materials. A forestry group was set up to consider what could be done to overcome the lack of cultivated area per capita and the urgent need to exploit animal and plant resources. In 1982, the group chose as its main study 'The Investigation into Huairou Plant Resources', out of which came a report entitled the 'Hairou Plant Retrieval Table'. During this study, the teachers directed students to reference materials, such as 'Beijing Plants Records' and 'Pictures of High-level Plants'. The students learnt the basic techniques of plant sorting and the use of the 'Plants Retrieval Table'. From 1982 to 1984, they identified 1,300 plants in Huairou, and wrote a 100,000 Chinese-character book entitled 'The Huairou Plant Retrieval Table', which includes 1,000 kinds of plants. Moreover, 600 types of plant specimens, including flowers and fruits, were collected.

Forestry activities have raised the students' interest. They have not only consolidated their knowledge and solved some urgent social problems, but have also developed their practical ability. In local competition, the group won a second prize in 1983 in the contest of 'Distinguishing Competence Among All Kinds of Arbor and Bush'. In 1984, one member of the group won the first prize in the individual context of 'Operational Skill and Competence in Biological Experiments'. In 1985, the group also won a first prize in the context of 'Distinguishing Competition Among One Hundred Kinds of Plants'. Moreover, the local government praised highly the report 'Plant Retrieval Table in Huairou'. The head of the Huairou Forest Bureau remarked 'To investigate the plant resources in Huairou County and to make a record of its plants has been my unfulfilled dream since the 1960s. Now your group has done this. It is a great contribution to the modernization of Huairou forests.'

Integrated Science

Students will be required to be good in some fields of study and also to be broadly knowledgeable and adaptable as the information society comes into being. Since an integrated knowledge of and ability in science cannot develop from the study of one subject, the experiments in integrated science are being given great and deserved attention. Currently, an integrated science curriculum is provided only in some key secondary schools, such as the Second Secondary School affiliated to the East China Normal University and the Secondary School affiliated to the North China Teacher's University, Beijing Jingshan School.

Example

By way of making a start, the Second Secondary School affiliated to the East China Normal University began integrated science teaching in 1984 through the teaching of physics, chemistry, biology and geography in out-of-class activities in grade one of the junior secondary school. The teachers insisted on students' making their own observations, records, and discussions. They encouraged students to study nature and society directly by, for example, making a natural investigation, visiting waste water processing stations, checking the purity of water and its processing in Shanghai, observing the living habitats of animals and their ecological environments, training students in the process of research and in solving practical social problems. Later, the school took integrated science as a subject and experimented in a class lasting two class hours once a week. To complement their studies, teachers asked students to do some reading and some out-of-class activities. This experiment went on for one year. The content of the work included:

An introduction to scientific method:

- Science around you;
- How to observe and describe;
- How to obtain a correct and reliable result;
- How to expand and strenthen your sensory organs.

A study of the world around us:

- Substance in nature;
- Life in nature;
- Phenomena in nature;
- Relationship between human beings and nature - environment and ecology.

How the environment is transformed.

The experiment has greatly raised students' interest in learning science and in using science. It has strengthened their skills in practical operations, their descriptive ability and their ability to learn by

confident that their practical work had developed their ability to solve problems. Some students wrote good essays during the experiment, on such topics as: 'Can a mouse learn?', 'How to make the water in a bottle flow at the greatest speed', 'The sensitivity to light of the human eye', etc.

Environmental Education

Environmental problems have become serious in many countries of the world. China is no exception. Current secondary school curricula in China, however, do not include, as a subject, environmental science. There are a few references to environmental problems in physics, chemistry and biology, but they lack system and coherence. To meet social needs, some schools are making experiments in environmental education, generally in the form of out-of-class activities, especially biological and chemical out-of-class activities. Only certain schools are providing environmental education as a subject.

Example one

From 1982, the Education Bureau and society of Zhangwu County, Liaoning Province, together with the environmental science society, have conducted environmental education in 16 secondary schools, 300 primary schools and some kindergartens in order to educate students systematically in the environment, to help students to become conscious of the need for environmental protection and to strengthen their environmental awareness. They synthetically and systematically considered every subject, and added the necessary environmental knowledge. Such knowledge is useful in helping students to understand better the basic knowledge in the textbooks. Through this additional work, the students' interest in and awareness of the need for environmental protection has been greatly developed.

Example two

The secondary school of Qishuyan Locomotive Vehicle Factory is located in Changzhou, Jiangsu Province. Changzhou is a new industrial city, but pollution has become a serious problem for it. The vehicle school accordingly decided to monitor the environment and to do so in students' out-of-class activities. Studies covered the effects of both the local agricultural and industrial production as well as the environment of local residents. The activities included a study of acid rain, of sulphuric dioxide and smog, the relationship between a residential environment and temperature, humidity, air-conditioning in the basements of buildings and environmental protection.

Service activities of environment protection have solved some practical social problems such as forecasting air pollution and weather. These have undoubtedly been valued by society. At the same time, the students' interest in learning and their enthusiasm for science were raised and their ability to tackle problems was strengthened.

Primary School Natural Science

Many experimental reforms are based on the belief that primary school science is a basic subject, the purpose of which is to educate students in the beginnings of science. Consequently the aim of imparting knowledge should be changed to the aim of educating. Numerous experimental textbooks have been written and are on trial all over the country.

Example

In order to encourage primary students to observe and experiment in their studies of nature, the Central Institute of Educational Research (CIER) has developed an experimental textbook and teaching reference books, designed to introduce science from grade one (normally, the subject is taught from grade three). The content is based on common things found in nature and on natural phenomena closely related to life and society. Nearly 90,000 students in 5,000 experimental schools in 26 provinces and cities are involved and 90 per cent of them were found to like nature classes the best. The earlier start appears not to burden the students. Rather, it seems to promote the learning of Chinese and of mathematics because the students find a greater interest in what schooling has to offer them.

Labour Education

Recently, education in the techniques of labour has been conducted in the following two forms in China:

The four-year junior secondary school

Normally the duration of junior secondary school is three years. After completing the three-year course, a year is added, with the specific purpose of learning some agricultural and industrial techniques. Alternatively, the three-year course is spread over four years and some socially needed knowledge combined with some cultural subjects are added to make up the four years;

Career classes in the general secondary school

At a certain stage in the junior or senior secondary school, students are allowed to enter various types of career classes. In career classes, the required cultural element is relatively less than in non-career classes, and students in a career class are mainly concerned with learning some specific labour techniques.

According to the regulations on education in the techniques of labour issued by the State Commission of Education, many schools have introduced experimental courses in accordance with local conditions.

Example

In order to impart proficiency in one particular line, the rural experimental secondary school of Liaoning Province has for a long time taught the techniques of agriculture, forestry and repair of household electrical appliances, one of which is a required subject. Having put these subjects into the curriculum, they have successfully set up an experimental practice centre, established a fruit garden, built a plastic shelter, some warm rooms, a fish pool, a carpenters shop, a sewing room, a weather garden and a school-run factory.

In recent years, the school has not only done much work on the effects of weather in agriculture but has investigated local resources, trained many primary technicians, and has become a local centre for introducing scientific experiments and teaching techniques. So far, they have introduced local farmers to some 10 different techniques of cultivation and have had good economic results. Since 1978, they have carried out 10 experiments involving more than 200 items every year. Their scientific results have won acclaim from the county and higher government. In particular their account entitled 'The Technique of Covering Paddy with Plastics' has won favourable comments from home and abroad.

Computer Education

China has been introducing computers into primary and secondary schools since 1987. Now there are over 36,000 microcomputers in some 3,000 primary and secondary schools. Including the out-of-school computers available to students, the total has now reached 60,000. They are mainly of Apple-II, LASER and COMX-35 type.

Currently, only a few key schools are teaching computer knowledge as a selective subject. The aims are to acquaint students with the principles and components of a microcomputer, to teach them one programming language (such as BASIC) and how to write a simple programme, to enable them to know how to operate a microcomputer and to use applied software. Computer Assisted Instruction (CAI) has received wide attention and certain achievements have been recorded.

Example

In order to impart basic knowledge of computers and how to use one to carry out some practical task, the No. 2 Secondary School affiliated to East China Normal University has carried out computer teaching experiments since 1978. The content mainly consists of instruction in BASIC and in some applied software (such as WORDSTAR and SPREADSHEET). The school has concentrated upon training students to solve problems. A few students are allowed to take part in the development and study of an applied project, such as the developing of CAI courseware and management software.

Computer education has made great progress in recent years. In 1983, the school won the first group prize in the Shanghai 'Youth Programming Competition'. In March, 1984, a few students won personal prizes in the second programming competition. The papers written by students have been compiled into a book. These papers cover wide fields: numerical value computing, Computer Assisted Instruction, duty processing, industrial control, graph systems and intellectual games. Some of them have played an important role in

student, overcomes the shortcomings of the Apple-II graphic system and can be directly used in many fields of production and daily life, such as drawing figures of machine parts and in decoration. In teaching, it can be used to draw maps, to instrument graphics and make figures of objects. Much biological, chemical and physical courseware has been developed using this common graphic system and products have been warmly welcomed by teachers and students.

Plans for Future Experiments

In order to make sure that the teaching of primary and secondary school mathematics, science and technology satisfies social needs, the following experiments are being planned.

An Experiment Project on 'Science, Technology and Society' (STS)

In order to achieve the aim of 'science for all', to relate the teaching of science and technology more closely to everyday life and to production and development, and to motivate the interest of students and develop their ability, our institute intends to introduce STS into several schools in Beijing and other provinces and cities. The following actions are planned:

Organizing a research group to study the teaching of STS. The group will include research workers at the CIER engaged in the pedagogy of physics, chemistry, biology and geography as well as some teachers in experimental schools. This group will be in charge of organizing and directing the teaching experiment.

Selecting as pilot schools five schools respectively affiliated to the Beijing Normal University, the East China Normal University, the Northeast Normal University, the Nanjing Normal University and one school in Sichuan Province.

Offering elective courses, according to specific conditions, in junior middle schools and senior middle schools to supplement existing unified science courses.

Choosing research topics as needed. Every experimental school may set up a compiling unit and the research group will be responsible for disseminating materials among these schools.

Designing a semester teaching plan for 2 learning hours per week (including the hour of experiment and practice).

Equipping experiment schools with simple STS laboratories.

Choosing practice places. This will be done by the experiment schools themselves.

A Project on Integrated Science

In order to achieve the aim of 'science for all' and to relate science teaching more closely to social life, production and development, our institute is planning a teaching experiment in Integrated Science Curriculum (ISC) in one school in Beijing and in other provinces and cities respectively.

During the first period (October, 1986 - October, 1988), $5,000 per year will be needed to carry out some basic studies on ISC. These studies will cover four broad areas of activity.

Collection of materials about ISC

Investigate the history of science curriculum development in China;
Investigate domestic reforms in school science curriculum in recent years;
Examine the effectiveness of on-going experiments on school science curriculum in China;
Investigate the history of science curriculum development in other countries;
Investigate textbooks of foreign ISC courses;
Examine the teaching of foreign ISC courses.

Investigation of social needs for science

Content: social production, life, etc.;
Locations: cities, rural areas and mountainous areas;
Participants: researchers, teachers and students.

Development of an integrated science textbook for the experiment in the second grades of junior middle schools

Develop Volume 1 of the integrated science textbook for the second grades of junior middle schools in 1987;
Develop Volume 2 of the integrated science textbook for third grades of junior middle schools in 1988;
Organize a compiling group consisting of researchers from the CIER, normal universities, and provincial educational institutes as well as researchers and teachers from some schools.

Teacher training

Carry out a teacher training programme (duration: one month) on the teaching of integrated science in 1988.
Coach teachers in the use of the new textbook, provide some information about ISC in the world;
Invite experts from the CIER, provincial educational institutes, normal universities at home and, we hope, one or two experts supplied by Unesco from abroad;
Budget, estimated at $15,000, made up of $2,000 for materials collection, $3,000 for social investigating, $4,000 for textbook development and $6,000 for training programmes.

During the second period (October, 1988-October, 1990) various teaching experiments will need $10,000 per year. During this period, a seminar will be held on teaching experiments in integrated science and an evaluation will be arranged in late 1990.

Appendix I

How Well Does Secondary Mathematics Meet the Social Needs?

In this analysis, the figure 1.00 implies 'essential', while the figure 0.00 implies 'unnecessary'; figures between these two are a measure of relative importance as judged by those who were consulted.

Mathematical Topics	Colleges	Research Institutes	Vocational Schools	Commerce	Rural	Army	Average
Conception of Rational Number	1.00	1.00	0.86	1.00	1.00	1.00	0.94
Calculation of Rational Number	1.00	1.00	0.80	0.90	0.92	1.00	0.94
Algebraic Expression	1.00	1.00	1.00	0.90	1.00	1.00	0.98
Integral Expression	1.00	0.80	0.86	0.90	0.92	1.00	0.91
Equation	0.88	1.00	0.93	0.90	0.92	1.00	0.94
First-degree Equation in One Variable	1.00	1.00	0.93	0.90	1.00	1.00	0.97
Inequality	0.88	1.00	1.00	0.90	0.92	1.00	0.95
Solutions of Inequality	0.65	0.80	1.00	0.80	0.67	1.00	0.82
Methods of Solving Inequality	0.82	1.00	0.93	0.90	0.92	1.00	0.93
First-degree Equation in Two Variables	1.00	1.00	1.00	0.80	1.00	1.00	0.97
The Substitution Method	1.00	1.00	1.00	0.80	1.00	1.00	0.97
The Addition-Subtraction Method	1.00	1.00	1.00	0.80	1.00	1.00	0.97
First-degree Equation in Three Variables	0.94	1.00	0.86	0.40	0.67	1.00	0.81
System of First-degree Equations	1.00	1.00	0.86	0.90	0.92	1.00	0.95
Multiplication and Division of Integral Expression	0.94	0.80	1.00	0.70	0.92	1.00	0.89
Formulae of Multiplication	1.00	1.00	1.00	0.90	1.00	1.00	0.98
Factoring	1.00	1.00	1.00	0.80	0.92	1.00	0.95
Fraction	0.76	1.00	1.00	0.80	1.00	1.00	0.93
Fractional Equation	0.58	1.00	0.86	0.80	0.92	1.00	0.86
Square Root and Cube Root	0.94	1.00	1.00	0.90	1.00	1.00	0.97
Real Number	1.00	1.00	1.00	0.80	1.00	1.00	0.97
Quadratic Radical	1.00	1.00	0.93	0.90	1.00	1.00	0.97
n-degree Radical	0.76	0.80	0.80	0.60	0.50	0.67	0.69
Quadratic Equation in One Variable	1.00	1.00	0.93	0.90	1.00	1.00	0.97

Appendix I (cont.)

The Discriminant of the Roots	1.00	1.00	0.86	0.80	0.92	1.00	0.93
Relations Between the Roots and Coefficients	0.94	1.00	0.86	0.70	0.92	1.00	0.90
Simple Equations of Higher Degree	0.65	1.00	0.67	0.60	0.67	1.00	0.76
Radical Equation	0.65	1.00	0.67	0.60	0.67	1.00	0.76
Quadratic Equation in Two Variables	0.65	0.60	0.80	0.60	0.75	0.25	0.60
Exponent	1.00	1.00	0.87	0.70	0.83	1.00	0.90
Logarithms	0.94	1.00	0.80	0.40	0.67	0.67	0.75
Common Logarithms	0.94	1.00	1.00	0.40	0.67	0.75	0.79
Rectangular Coordinates System	0.94	1.00	0.93	0.50	0.92	0.75	0.84
Concept of Function	0.88	0.60	0.93	0.60	0.83	1.00	0.81
Direct Variation and Inverse Variation	0.88	0.60	1.00	0.60	1.00	1.00	0.85
Linear Function	0.88	0.60	0.73	0.60	0.92	1.00	0.79
Quadratic Function	0.82	0.60	0.60	0.50	0.67	1.00	0.70
First-degree Inequality in One Variable	0.58	0.40	1.00	0.60	0.75	0.75	0.68
Trigonometric Function	0.82	1.00	1.00	0.60	0.75	0.75	0.82
Solving Right Triangle	0.94	1.00	1.00	0.60	0.92	0.75	0.87
Solving Oblique Triangle	0.76	0.80	0.60	0.60	0.67	0.75	0.70
Elementary Statistics	0.41	0.20	0.93	0.70	0.50	0.75	0.58
Geometric Figures	1.00	1.00	0.93	0.70	1.00	0.75	0.90
Conception of Straight Line	1.00	1.00	0.93	0.70	1.00	0.75	0.90
Conception of Segments and Rays	1.00	1.00	0.86	0.70	1.00	1.00	0.93
Perpendicular Lines	1.00	1.00	0.93	0.70	1.00	0.75	0.90
Conception of Corresponding Angles	1.00	1.00	0.93	0.70	0.92	0.75	0.89
Parallel Lines	1.00	1.00	0.93	0.70	0.92	0.75	0.89
Theorem and proposition	1.00	1.00	0.93	0.80	0.83	0.75	0.89
Conception of Triangle	1.00	1.00	0.93	0.70	1.00	1.00	0.94
Relationship of Sides and Angles of Triangle	1.00	1.00	0.93	0.70	1.00	0.75	0.90
Isosceles Triangle	0.94	1.00	1.00	0.60	1.00	1.00	0.92
Drawing Figures	1.00	1.00	0.80	0.80	1.00	1.00	0.93
Right Triangle	1.00	1.00	1.00	0.70	1.00	1.00	0.95
Converse Proposition and Theorem	0.94	1.00	1.00	0.70	0.67	0.75	0.84
Angular Bisector	1.00	1.00	1.00	0.80	1.00	1.00	0.96
Axisymmetric Figures	0.76	0.60	1.00	0.80	0.92	0.75	0.81
Polygon	0.82	1.00	1.00	0.70	0.92	0.75	0.87

Appendix I (cont.)

Parallelogram	1.00	1.00	1.00	0.70	1.00	1.00	0.95
Central Symmetric Figures	0.76	0.40	1.00	0.70	0.75	1.00	0.77
Trapezoid	0.94	1.00	0.86	0.70	1.00	0.75	0.88
Theorem of Intercepting Equal Parts	1.00	1.00	1.00	0.80	1.00	0.75	0.93
Theorem of Median of a Trapezoid	0.94	1.00	1.00	0.70	1.00	0.75	0.90
Area of Parallelogram	0.94	1.00	1.00	0.80	0.92	1.00	0.94
Pythagorian Theorem	1.00	1.00	1.00	0.70	1.00	0.75	0.91
Properties of Proportion	1.00	1.00	1.00	0.80	1.00	/	0.96
Theorem of Proportion	1.00	1.00	1.00	0.80	1.00	/	0.96
Similar Triangles	1.00	1.00	0.93	0.70	1.00	/	0.93
Similar Polygons	0.82	1.00	0.93	0.70	0.75	/	0.84
Homothetic Figures	0.29	0.20	0.93	0.80	0.41	0.00	0.43
Conception of Circles	1.00	1.00	1.00	0.80	1.00	0.75	0.93
Point and Circle	1.00	1.00	1.00	0.70	1.00	0.75	0.91
Regular Polygons and Circle	0.82	1.00	1.00	0.70	1.00	0.75	0.88
Relations Between the Four Propositions	0.76	0.80	1.00	0.70	0.50	0.75	0.75
Locus	0.88	0.40	0.93	0.40	0.67	1.00	0.71
Plan and Elevation	0.58	0.40	0.67	0.50	0.41	0.75	0.55

Appendix II

Mathematical Topics found in 76 kinds of Magazines.
Their frequency of occurrence in each of six broad areas of concern.

Mathematical Topic	Social Science			Natural Science			Total
	Philosophy	Cultural & Education	Economy	Science	Technology	Medicine & Agriculture	
Fraction and Decimal Operation	137	345	47	151	338	61	1 079
Proportion and Percentage	216	607	264	551	236	467	2 339
Rational Number Operation	10	2	39	53	175	84	363
Real Number Operation	8	0	3	22	142	59	234
Approximate Calculation	2	0	0	1	15	0	18
Logarithm Operation	6	0	2	6	1	14	29
Complex Number Operation	0	0	0	5	0	0	5
Power	2	0	0	1	0	0	3
First-degree Equation in One Variable	0	0	56	18	63	2	139
Quadratic Equation in one Variable	14	2	3	1	0	15	25
Relations between the Roots and Coefficients of a Quadratic Equation	0	0	0	0	0	0	0
Higher Degree Equation in one Variable	0	0	0	0	0	0	0
Fractional Equation	2	2	26	32	64	1	129
Irrational Equation	1	3	9	98	19	17	117
Determinant	0	0	0	1	0	0	1
Systems of Simple Equations	0	1	3	5	1	0	10
Exponent Equation	0	1	0	1	0	0	2
Logarithm Equation	0	0	0	2	4	0	6
Trigonometric Equation	0	0	0	2	0	0	2
Quadratic Equation in Two Variables	0	0	0	0	0	1	1
Solutions as Complex Numbers	0	0	0	2	0	0	2
First-degree Inequality in One Variable	1	0	7	19	37	8	72
Quadratic Inequality in One Variable	3	0	0	3	0	0	6

Appendix II (cont.)

System of First-degree Inequalities	3	0	1	5	2	0	13
Absolute Value Inequality	0	0	0	5	0	1	6
Fractional Inequality	0	0	0	0	0	1	1
Irrational Inequality	0	0	1	2	1	2	6
Rectangular Cartesian Coordinate	103	1	4	13	97	5	223
First-degree Function	1	8	10	56	46	38	159
Quadratic Function	3	0	0	2	11	0	16
Power Function	1	0	0	3	2	1	7
Exponential Function	1	0	1	8	0	5	15
Logarithmic Function	7	0	0	8	7	1	23
Trigonometrical Function	8	0	1	7	69	4	89
Inverse Function	2	0	0	2	7	1	12
Solving Right Triangle	2	0	0	0	12	0	14
Solving Oblique Triangle	0	0	0	2	1	0	3
Arithmetic Sequence	0	0	1	1	0	1	3
Geometric Sequence	0	0	9	2	0	0	11
Mathematical Induction	0	0	0	3	0	0	3
Arithmetic Sequence of Higher Degree	0	0	0	0	0	0	0
Binomial Theorem	0	0	0	7	0	0	7
Matrix	0	1	0	4	1	5	11
Matrix Operation	0	0	0	3	0	1	4
Inverse Matrix	0	0	0	0	0	0	0
Matrix Algebra	0	0	0	0	0	0	0
Vector Addition	0	0	0	2	2	0	4
Vector Product	0	0	0	0	0	0	0
Conception of Set	5	0	1	0	0	2	8
Set Operation	0	0	0	0	0	0	0
Correspondence	0	1	0	0	0	0	1
Mapping	0	0	0	0	0	0	0
Simple Statistic Chart	225	53	172	182	196	290	1 117
Variance	2	2	14	1	0	28	47
Random Probability	4	2	15	1	0	3	25
Condition Probability	0	0	0	5	0	0	5
Addition of Probability	2	0	5	0	0	3	10
Sampling Analysis	8	0	17	1	0	10	36

Appendix II (cont.)

Regression Analysis	3	0	2	2	0	30	37
Property of Triangle	4	0	0	10	4	1	19
Property of Quadrilateral	1	1	0	1	0	0	3
Property of Circle	0	2	0	6	15	2	25
Similar Figures	0	0	0	0	1	1	2
Symmetry Figures	0	0	0	2	0	0	2
Simple Formal Logic	0	0	0	0	0	0	0
Drawing Figures with Rule and Compasses	0	0	0	3	8	1	12
Drawing Figures with Instrument	0	0	0	0	7	1	8
Calculation of Area	0	2	0	1	4	1	8
Positional Relations Between a Line and a Plane	0	0	0	0	4	0	4
Positional Relations Between Two Planes	0	0	0	0	0	0	0
Polyhedron	1	8	0	9	18	2	38
Solid of Rotation	0	2	0	1	4	1	8
Plan and Elevation	0	0	0	0	129	4	133
Direct View	0	0	0	0	0	0	0
Parametric Equation of Straight Line	1	0	0	1	1	0	3
System of Straight Lines	0	0	0	0	0	0	0
Coordinates	0	0	0	0	0	0	0
Conic	1	0	0	6	4	1	12
Length of Tangent	0	0	0	0	0	0	0
Length of Normal	0	0	0	0	0	0	0
Translation of Axes	0	0	0	0	0	0	0
Rotation of Axes	0	0	0	2	0	0	2
Parametric Equation	0	0	0	3	0	0	3
Polar Equation	0	0	0	0	0	0	0
Elementary Analytic Geometry in Space	0	0	0	0	3	0	3
Limit of a Sequence	0	0	0	0	0	0	0
Limit of a Function	0	0	1	5	2	1	9
Differential	1	0	3	8	9	28	49
Drawing Figures of Functions	0	0	20	0	0	0	20
Expansion of Function	0	0	2	0	0	0	2
Approximate Solution of Equation	0	0	0	0	0	0	0
Indefinite Integral	0	0	0	9	2	10	21

Appendix II (cont.)

Integral Table	0	0	0	0	0	0	0
Numerical Integral	0	0	0	0	0	0	0
Definite Integral	0	0	5	11	7	3	26
First Order Ordinary Differential Equation	0	0	0	2	2	6	10
Second Order Ordinary Differential Equation	0	0	0	0	0	8	8
Carrying Number System	0	0	0	5	6	1	12
Logic Algebra	0	0	0	0	2	1	3
Flow Chart	0	0	1	4	0	3	8
Design of Simple Programme	0	0	0	0	0	0	0
BASIC Language	7	3	1	46	6	3	66
Calculator	0	0	0	0	0	0	0
Optimum Seeking Method	0	0	0	0	0	0	0
Operational Research	0	0	0	0	0	0	0
Linear Programming	0	0	0	0	0	0	0
Combinatorial Theory	0	0	0	0	0	0	0

From: The Maths Division of Curriculum and Teaching Materials Research Institute, Investigation Results on How Far Mathematics Meets the Social Needs, November 1986, pp. 18-23.

Appendix III

How Well Does Secondary Physics Meet the Social Needs?

In judging the relative importance of the items in dispute, 3.0 was taken to imply 'needing quantitative mastery', 2.0 for 'needing qualitative mastery', 1.0 indicates 'less necessary' and 0.0 implies 'unnecessary'.

Topics	Electronics	Machinery	Fuel Industry	Culture & Education	Army	Textile Industry	Geology & Mineral	Communic-ations	Agri-culture
Concept of Significant Figure	2.2	2.2	2.4	1.8	1.9	2.2	2.1	1.3	1.9
Operation of Significant Figure	2.1	2.2	2.5	1.8	1.9	2.2	2.1	1.3	1.9
Principle of Square Calliper	1.6	1.6	1.4	1.0	0.9	2.1	1.9	2.4	1.8
Using Square Calliper	1.9	2.0	1.6	1.0	1.2	2.2	2.0	2.4	1.9
Concepts of Resultant and Component of Forces	1.9	2.2	2.1	2.2	2.2	2.0	2.1	2.0	1.9
Methods of Resultant and Component of Forces	1.9	2.2	2.0	2.2	2.1	1.9	1.8	2.0	1.9
Stable Equilibrium	1.6	1.5	1.7	1.6	1.6	1.8	1.9	1.6	1.5
Unstable Equlibrium	1.5	1.5	1.7	1.5	1.6	1.8	1.6	1.6	1.4
Neutral Equilibrium	1.4	1.5	1.7	1.4	1.4	1.7	1.3	1.6	1.3
Coefficient of Friction of Rest	1.6	2.0	2.0	1.7	1.9	2.0	0.5	1.9	1.6
Relation Between Pressure Intensity and Flow Velocity	1.5	1.8	2.1	1.8	2.0	1.9	2.1	1.9	1.7
Relative Velocity	1.5	1.7	1.8	1.5	2.0	2.0	1.9	1.8	1.7
Kepler's Laws	1.2	1.4	1.4	1.4	1.4	1.7	1.4	1.3	1.2
Mechanical Drive	1.9	2.3	2.1	1.6	2.0	2.3	2.2	2.1	1.6
Concept of Simple Periodic Motion	1.9	1.5	1.5	1.7	1.0	1.5	1.3	1.0	1.1
Law of Simple Periodic Motion	1.9	1.5	1.3	1.7	1.9	1.5	1.3	1.0	1.1
Calculation of Simple Periodic Motion	1.5	1.4	1.2	1.4	1.2	1.3	0.9	1.0	0.8
Simple Pendulum	1.5	1.4	1.2	1.8	1.4	1.3	0.8	1.0	0.8
Stationary Wave	1.6	1.1	1.6	1.3	1.0	1.5	0.9	0.5	0.6
Doppler Effect	1.5	1.1	1.6	1.2	1.0	1.5	1.1	0.5	0.7
Noise	2.0	1.7	1.3	1.5	1.5	1.8	1.3	1.0	1.2

Appendix III (cont.)

Decible	2.1	1.8	1.4	1.5	1.5	1.9	1.2	1.0	1.2
Ultrasonic and Infrasound	1.4	1.2	1.0	1.5	1.5	1.2	1.0	0.9	1.2
Use of Ultrasonic	1.4	1.2	1.1	1.5	1.6	1.2	1.0	1.1	1.3
Concept of Thermal Expansion	1.6	2.0	2.0	1.7	1.7	2.0	2.1	1.9	1.7
Calculation of Thermal Expansion	1.6	2.0	2.0	1.7	1.5	2.0	2.1	1.7	1.7
Linear Expansion	1.6	2.0	1.9	1.7	1.5	2.0	2.1	1.7	1.7
Volumetric Expansion	1.6	2.0	1.9	1.7	1.5	2.0	2.1	1.7	1.7
Osmosis	1.2	1.3	1.6	1.7	1.3	1.8	1.9	1.1	2.0
Diffuseness	1.3	1.4	1.7	1.6	1.5	1.8	1.8	1.1	2.0
Surface Density	1.1	1.3	1.7	1.2	1.4	1.8	1.7	1.1	1.9
Phenomenon of Infiltration	1.1	1.2	1.7	1.3	1.2	1.7	1.7	1.1	1.9
Phenomenon of Capillary	1.1	1.4	1.8	1.2	1.3	2.1	1.9	1.0	1.9
Stretcher Strain	1.3	2.0	1.9	1.3	1.7	2.1	2.2	1.9	1.7
Shear Transformation	1.2	1.8	1.6	1.2	1.5	2.2	2.1	1.5	1.4
Bending Creep	1.2	2.0	1.7	1.3	1.8	2.2	2.3	1.9	1.5
Torsional Shape Change	1.2	1.9	1.9	1.3	1.6	2.2	2.2	1.9	1.6
Saturation Vapour	1.0	1.2	1.8	1.2	1.5	2.2	2.0	1.0	1.8
Supersaturation Vapour	1.0	1.3	1.8	0.9	1.5	2.2	2.0	0.8	1.7
Dew-point	1.0	1.2	1.7	0.9	1.3	2.2	1.9	0.8	1.8
Humidity	1.4	1.5	1.9	1.3	1.5	2.2	2.0	0.9	2.0
Refrigeration	1.3	1.3	1.9	1.4	1.4	2.3	1.8	0.6	1.6
First Law of Thermodynamics	1.4	1.7	1.9	1.9	1.8	2.3	2.1	0.9	1.7
Second Law of Thermodynamics	1.3	1.6	2.1	1.5	1.7	2.3	2.3	0.9	1.7
Capacitors in Series and in Parallel	2.3	2.2	1.8	2.1	2.3	2.3	2.1	1.5	1.8
Lightening and Lightening Protection	1.7	1.6	2.1	1.5	1.8	2.2	2.0	0.9	1.8
Concept of Electromotance	2.3	2.0	2.2	2.1	2.3	2.2	2.0	1.5	1.6
Measurement of Electromotance	2.4	1.9	1.7	2.1	2.4	2.1	2.0	1.5	1.6
Meaning of Kirchhoff's Laws	2.4	1.8	1.7	1.6	1.6	1.5	1.5	1.4	0.9
Use of Kirchhoff's Laws	2.4	1.8	2.2	1.6	1.7	1.7	1.5	1.4	1.0
Principle of Universal Meter	2.4	2.0	2.3	2.1	2.4	2.3	2.3	2.4	1.9
Use of Universal Meter	2.6	2.1	2.0	2.1	2.7	2.4	2.3	2.4	2.0
Principle of Wheatstone Bridge	2.0	1.7	2.1	1.8	1.7	1.8	1.7	1.3	1.1
Use of Wheatstone Bridge	2.1	1.7	2.2	1.7	1.6	1.8	1.7	1.3	1.2
Ohm's Law	2.6	2.2	1.7	2.4	2.6	2.1	2.0	2.0	1.9
Electric Arc	1.8	1.5	1.6	1.7	1.9	1.9	1.8	1.3	1.3

Appendix III (cont.)

Low-pressure Discharge	1.7	1.5	1.9	1.6	1.9	1.9	1.6	1.4	1.1
Faraday's Laws of Electrolysis	1.8	1.5	1.6	1.9	1.9	1.9	1.8	1.1	1.4
Structure of Dry Cell	1.7	1.4	1.6	1.6	2.2	1.9	1.8	1.6	1.6
Use of Dry Cell	1.9	1.5	1.7	1.6	2.1	1.8	1.9	1.6	1.7
Accumulator Structure	1.7	1.4	1.8	1.6	2.2	1.9	1.9	2.3	1.7
Use of Accumulator	1.9	1.6	1.7	1.6	2.3	2.0	1.9	2.3	1.8
Photocell	1.8	1.2	2.1	1.6	1.9	1.9	1.7	1.3	1.4
Structure of Semi-diode	2.5	1.7	2.0	1.9	2.4	2.1	2.0	1.4	1.6
Function of Semi-diode	2.5	2.0	2.0	2.1	2.6	2.1	2.0	1.6	1.6
Use of Semi-diode	2.6	2.0	1.9	1.9	2.5	2.1	2.0	1.4	1.6
Structure of Semi-triode	2.5	1.9	1.9	1.9	2.4	2.0	2.0	1.4	1.5
Use of Semi-triode	2.5	1.9	1.7	1.9	2.5	2.1	2.0	1.4	1.5
Type of On-off Circuit	2.5	1.9	1.9	1.9	2.3	2.3	1.8	1.1	1.8
Function of On-off Circuit	2.5	1.9	1.8	1.8	2.4	2.3	1.8	1.1	1.8
Type of Gating Circuit	2.3	1.7	1.8	1.6	2.1	1.9	1.3	0.7	1.2
Function of Gating Circuit	2.3	1.7	1.5	1.6	2.1	1.9	1.3	0.7	1.3
Geomagnetic Field	1.4	0.6	0.5	1.2	1.4	1.1	1.1	0.0	0.6
Lorentz Force	1.4	0.6	0.5	1.6	1.3	1.1	1.1	0.0	0.6
Structure of Cyclotron	0.7	0.4	0.5	1.1	0.6	0.9	0.8	0.1	0.5
Principle of Cyclotron	0.8	0.4	0.5	1.1	0.6	0.9	0.8	0.1	0.5
Function of Cyclotron	0.8	0.4	0.5	1.1	0.6	0.9	0.8	0.1	0.5
Structure of Mass Spectrometer	0.8	0.7	1.0	0.8	0.8	0.8	1.0	0.0	0.6
Principle of Mass Spectrometer	0.8	0.6	1.3	0.8	0.8	0.8	1.0	0.0	0.6
Function of Mass Spectrometer	0.9	0.6	1.6	0.8	0.8	0.8	1.0	0.0	0.6
Phenomenon of Self-inductance	2.2	1.6	1.5	1.7	2.1	1.4	1.9	1.1	1.3
Calculation of Self-inductance	2.2	1.6	1.5	1.7	2.1	1.4	1.9	1.1	1.3
Use of Self-inductance	2.2	1.6	1.5	1.6	2.1	1.5	1.9	1.1	1.3
Phenomenon of Mutual-inductance	2.2	1.7	1.6	1.5	2.2	1.6	1.9	1.4	1.2
Calculation of Mutual-inductance	2.3	1.7	1.5	1.6	2.1	1.6	1.9	1.4	1.2
Use of Mutual-inductance	2.3	1.8	1.5	1.6	2.3	1.6	1.9	1.4	1.3
Phase Position Between Alternating Current and Voltage	2.6	1.0	2.2	1.6	1.9	1.6	1.3	0.7	1.2
Concept of Power Factor	2.1	2.0	2.3	1.8	2.2	2.2	1.9	1.6	1.8
Calculation of Power Factor	2.1	2.0	2.2	1.9	2.2	2.2	1.9	1.6	1.8

Appendix III (cont.)

Producing of Triphase Alternating Current	2.2	1.9	2.3	1.9	2.1	2.4	1.9	1.9	1.9
Calculation of Triphase Alternating Current	2.4	2.1	1.9	1.9	2.1	2.4	1.9	1.9	1.9
Use of Triphase Alternating Current	2.4	2.1	1.9	1.9	2.2	2.5	1.9	1.9	2.0
Power Transmission	2.1	1.3	2.1	1.3	1.4	1.9	1.3	3.0	1.2
Principle of Transformer	2.4	2.1	2.0	1.9	2.3	2.0	1.9	1.5	1.8
Structure of Transformer	1.5	2.0	1.9	1.8	2.2	2.2	1.9	1.5	1.8
Calculation of Transformer	1.5	1.9	1.7	1.8	2.2	2.2	1.9	1.5	1.7
Structure of Generator	1.5	1.6	1.8	1.4	2.3	1.6	2.1	2.3	1.7
Principle of Generator	1.5	1.7	1.8	1.4	2.3	1.6	2.1	2.3	1.7
Structure of D.C. Motor	1.7	1.9	1.8	1.3	2.5	1.8	1.8	2.2	1.7
Principle of D.C. Motor	1.9	1.9	1.8	1.4	2.5	1.7	1.8	2.1	1.7
Structure of A.C. Motor	1.7	1.9	1.8	1.2	1.9	2.1	1.8	2.1	1.6
Principle of A.C. Motor	1.8	1.7	1.8	1.3	1.9	2.1	1.8	2.1	1.5
Principle of T.V.	1.8	1.3	1.2	1.7	2.0	1.4	1.7	0.9	1.3
Principle of Video Recorder	1.6	1.2	1.2	1.8	2.0	1.3	1.6	0.9	1.2
Principle of Tape Recorder	1.9	1.3	1.6	1.9	2.1	1.3	1.6	0.7	1.5
Light Intensity	1.4	1.2	1.5	1.7	1.7	1.4	1.5	0.8	1.4
Illumination	1.4	1.0	1.2	1.6	1.8	1.4	1.5	0.8	1.4
Images of Plane Mirror	1.1	1.2	1.2	1.7	1.7	1.3	1.4	0.9	1.3
Images of Curved Mirror	1.0	1.1	1.2	1.7	1.7	1.3	1.4	0.9	1.2
Composition of Lenses	1.0	0.9	1.1	1.8	1.7	1.2	1.8	1.0	1.4
Structure of Eyes	0.9	1.0	1.4	2.1	1.9	1.3	1.8	0.9	1.4
Magnifying Glass	1.0	1.1	0.7	2.0	1.9	1.2	1.9	0.9	1.7
Structure of Epidiascope	0.7	0.9	0.8	1.8	1.4	1.0	1.1	0.4	1.2
Principle of Epidiascope	0.8	0.8	0.7	1.8	1.5	0.9	1.1	0.5	1.3
Use of Epidiascope	0.7	0.7	1.1	1.7	1.5	0.9	1.1	0.4	1.5
Structure of Camera	1.0	1.0	1.1	1.9	1.9	1.1	1.9	1.3	1.9
Principle of Camera	1.1	1.1	1.1	2.0	1.9	1.1	1.9	1.3	1.9
Use of Camera	1.1	1.0	1.0	2.0	2.0	1.2	2.0	1.3	2.1
Structure of Telescope	0.7	0.8	1.0	1.5	1.8	1.0	1.8	0.6	1.3
Principle of Telescope	0.8	0.8	0.9	1.6	1.7	1.0	1.8	0.6	1.4
Use of Telescope	0.8	0.9	1.2	1.5	1.8	1.0	1.8	0.6	1.4
Structure of Microscope	0.9	1.2	1.2	1.8	1.4	1.3	2.1	1.0	1.3
Principle of Microscope	1.0	1.2	1.2	1.8	1.4	1.3	2.1	1.0	1.8
Use of Microscope	1.0	1.2	1.0	1.7	1.3	1.5	2.1	1.0	1.5

Appendix III (cont.)

Polarization	0.8	0.8	1.0	1.1	1.1	1.2	1.1	0.5	0.5
Laser	1.2	1.0	0.6	1.5	1.4	1.1	1.2	0.9	1.0
Holography	0.9	0.7	0.9	1.2	1.3	1.0	1.1	0.5	0.7
Simple Introduction of Special Relativity	0.7	0.7	0.8	0.7	1.0	1.0	1.2	0.6	0.5
Simple Introduction of Quantum Theory	1.1	0.7	1.0	0.8	1.0	1.1	1.1	0.5	0.5
Simple Introduction of Solid-state Theory	0.9	0.8	0.9	0.8	0.9	1.1	1.0	0.8	0.6
Radioactive Pollution	1.0	0.9	1.1	1.4	1.2	1.1	1.5	0.8	0.8

Appendix IV

How Well Does Secondary Chemistry Meet Social Needs in Suburban Areas?

Topics	Necessary	Per Cent	Less Necessary	Per Cent	Unnecessary	Per Cent	No Idea	Per Cent
Atom, Molecule and Element	106	25.7	122	29.6	151	36.7	33	8.0
Symbol for Element	112	27.2	128	31.1	150	36.4	22	5.2
Law of Conservation of Mass	77	18.6	114	27.7	184	44.7	37	9.0
Oxidizing and Reducing Agents	109	26.5	95	23.1	165	40.0	43	10.4
Chemical Combination and Decomposition	87	21.2	99	24.0	179	43.4	47	11.4
Solutions	107	26.2	104	25.2	170	41.2	31	7.4
Ionic Compound and Covalent Compound	60	14.6	122	29.3	175	42.4	55	13.7
Percentage Concentration	117	28.3	107	26.0	172	41.8	56	3.9
Neutral Reaction	131	31.8	95	23.1	167	40.5	19	4.6
Oxidation-reduction Reaction	73	17.7	107	26.0	209	50.7	23	5.6
Oxidation	103	25.0	100	24.3	168	40.7	41	10.0
Air, Oxygen, Hydrogen, Nitrogen	126	30.6	115	27.9	139	33.7	32	7.8
Water	128	26.2	125	30.3	148	35.9	31	7.6
Carbon, Monoxide, Dioxide	95	23.1	128	31.1	163	39.5	26	6.3
Acids	96	23.3	118	28.6	168	40.8	30	7.3
Chemical Fertilizer	48	11.7	88	21.4	226	54.8	50	12.1
Calculation According to Chemical Formulae	88	21.4	88	21.4	178	43.2	58	14.0
Calculation of Solubility	101	24.6	99	24.0	174	42.2	38	9.2
Use of Ordinary chemical Instruments	106	25.7	103	25.0	163	39.6	40	9.7
Separation of Substances	101	24.6	85	20.6	186	45.1	40	9.7
Making up Solutions	114	27.7	81	19.7	174	42.2	43	10.4
Appraisal	110	26.7	83	20.1	154	37.4	65	15.8

Appendix V

How Well Secondary Chemistry Meets Social Needs in Rural Areas?

Topic	Necessary	Per Cent	Less Necessary	Per Cent	Unnecessary	Per Cent	No Idea	Per Cent
Atom, Molecule and Element	12	23.0	13	25.0	26	50.0	1	2.0
Symbol for Element	8	15.0	36	69.0	6	12.0	2	4.0
Law of Conservation of Mass	12	23.0	31	59.0	9	17.0	0	0.0
Oxidizing and Reducing Agents	11	21.0	23	44.0	17	33.0	1	2.0
Chemical Combination and Decomposition	12	23.0	20	38.0	12	23.0	8	15.0
Solutions	13	25.0	13	25.0	16	31.0	10	19.0
Ionic Compound and Covalent Compound	3	6.0	17	33.0	20	39.0	12	23.0
Percentage Concentration	14	27.0	23	44.0	12	23.0	3	6.0
Neutral Reaction	11	21.0	22	41.0	16	31.0	3	6.0
Oxidation-reduction Reaction	3	6.0	19	37.0	21	40.0	9	17.0
Oxidation	17	33.0	20	39.0	15	29.0	0	0.0
Air, Oxygen, Hydrogen, Nitrogen	19	37.0	23	44.0	10	19.0	0	0.0
Water	18	35.0	19	37.0	13	25.0	2	4.0
Carbon, Monoxide, Dioxide	9	17.0	21	40.0	20	38.0	2	4.0
Acid	18	35.0	18	35.0	12	23.0	3	6.0
Chemical Fertilizer	19	37.0	25	48.0	6	12.0	2	4.0
Calculation According to Chemical Formulae	13	25.0	17	33.0	19	37.0	3	6.0
Calculation of Solubility	17	32.0	23	44.0	11	22.0	1	2.0
Use of Ordinary Chemical Instruments	12	23.0	16	31.0	21	40.0	3	6.0
Separation of Substance	12	23.0	17	33.0	18	35.0	5	9.0
Making up Solution	19	37.0	22	42.0	10	19.0	1	2.0
Appraisal	12	23.0	19	37.0	19	37.0	2	4.0

Appendix VI

How Well Does Secondary Biology and Physiological Hygiene Meet Social Needs?

Topics	Necessary	Per Cent	Less Necessary	Per Cent	Unnecessary	Per Cent
Cell	238	99.2	2	0.8	0	0.0
Tissues and Organs	208	86.7	13	5.4	19	7.9
Structures of Seeds	232	96.7	7	2.9	1	0.4
Components of Seeds	229	59.4	9	3.8	2	0.8
Germination of Seeds	207	86.2	14	5.8	19	7.9
Life of seeds	51	21.2	56	23.3	133	55.4
Shape of Roots	76	31.7	108	45.0	56	23.3
Structure of Roots	218	90.8	15	6.2	7	2.9
Water Absorbed by Roots	137	57.1	66	27.5	37	15.4
Inorganic Salt Absorbed by Roots	109	45.4	76	31.7	55	22.9
Shape of Leaves	167	69.6	55	22.9	18	7.5
Structure of Leaves	221	92.1	12	5.0	7	2.9
Photosynthesis of Leaves	184	76.7	37	15.4	19	7.9
Breathing of Leaves	106	44.2	76	31.7	58	24.2
Transpiration of Leaves	133	55.4	65	27.1	32	13.3
Growth of Stems	106	44.2	76	31.7	58	24.2
Shape of Stems	194	80.8	34	14.2	12	5.0
Structure of Stems	226	94.2	11	4.6	3	1.2
Movement of Stems	187	77.9	41	17.1	12	5.0
Reproduction of Stems	50	20.8	78	32.5	112	46.7
Structure of Flowers	228	95.0	11	4.6	1	0.4
Kinds of Flowers	69	28.8	76	31.7	95	39.6
Pollination	150	62.5	52	21.7	38	15.8
Fertilization	216	90.0	21	8.8	3	1.2
Structure of Fruits	77	32.1	87	36.2	76	31.7
Relationship between Fruit, Leaf, Root and Stem	55	22.9	91	37.9	94	39.2
Principles of Plant Classification	37	15.4	89	37.1	114	47.5
Major Orders of Green Flowering Plants	15	6.2	73	30.4	152	63.3

Appendix VI (cont.)

Green Algae	106	44.2	76	31.7	58	24.2
Other Algae	13	5.4	37	15.4	190	79.2
Bacteria	158	65.8	54	22.5	38	15.8
Actinomyces	58	24.2	88	36.7	94	39.2
Fungi	60	25.0	87	36.2	93	38.8
Semiepiphytes	53	22.1	92	38.2	95	39.6
Pteridophytes	99	41.2	64	26.7	77	32.1
Gymnosperms	51	21.2	92	38.3	97	40.4
Seed Plants	137	57.1	56	23.3	37	15.4
Evidence of Evolution of Plants	72	30.0	76	31.7	92	38.3
Reasons for Evolution of Plants	45	18.8	84	35.0	111	46.2
Aquatic Plants	22	9.2	57	23.8	161	67.1
Forest Growth	20	8.3	58	24.2	162	67.5
Characteristics of the Phytocommunity	23	9.6	57	23.8	160	66.7
Geographic Distribution of the Phytocommunity in China	158	65.8	49	20.4	33	18.3
Plants Resources in China	157	65.4	51	21.2	32	13.3
Protection of Plant Resources	167	69.6	37	15.4	46	19.2
Protozoa	170	70.8	51	21.2	19	7.9
Coelenterata	169	70.4	53	22.1	18	7.5
Turbellaria	75	31.2	89	37.1	76	31.7
Tapeworms	135	56.2	48	20.0	57	23.8
Blood Fluke	21	8.8	57	23.8	162	67.5
Roundworm	191	79.6	31	12.9	18	7.5
Hookworm	30	12.5	76	31.7	134	55.8
Annelida	200	83.3	27	11.2	13	5.4
Mollusca	157	65.4	46	19.2	37	15.4
Insects	222	92.5	13	5.4	5	2.1
Crustacea	180	75.0	36	15.0	24	10.0
Myriapoda	42	17.5	103	42.9	95	39.6
Echinoderm	43	17.9	101	42.1	96	40.0
Lancelet	199	82.9	22	9.2	19	7.9
Crucian Carp	221	92.1	16	6.7	3	1.2
Varied Fishes	28	11.7	79	32.9	133	55.4
Fresh Water Fish-farming	21	8.8	67	27.9	152	63.3

Appendix VI (cont.)

Fishing in the Sea	14	5.8	65	27.1	161	67.1
Frog	195	81.2	38	15.8	17	7.1
Other Amphibians	173	72.1	47	19.6	19	7.9
Chinese Montane Lizard	201	83.8	26	10.8	13	5.4
Reptiles	21	8.8	84	35.0	135	56.2
Pigeons	137	57.1	46	19.2	57	23.8
Birds	103	42.9	63	26.2	74	30.8
Reproduction in Birds	68	28.3	77	32.1	95	39.6
Migration of Birds	11	4.6	66	27.5	163	67.9
Protection of Birds	147	61.2	42	17.5	51	21.2
The Origin of Birds	123	51.2	39	16.2	78	32.5
Rabbits	198	82.5	23	9.6	19	7.9
Monotremata	127	52.9	57	23.8	56	23.3
Whales	69	28.8	76	31.7	95	39.6
Carnivores	134	55.8	49	20.4	57	23.8
Perissodactyla and Artiodactyla	139	57.9	51	21.2	50	20.8
Primates	149	62.1	59	24.6	32	13.3
Protection of Mammals	162	67.5	47	19.6	31	12.9
Evidence and Process of Animal Evolution	136	56.7	48	20.0	56	23.3
The Origin of Mankind	145	60.4	43	17.9	52	21.7
Geographical Distribution of Animals in China	193	80.4	32	13.3	15	6.2
The Human Body	237	98.8	3	1.2	0	0.0
Structure of the Skin	233	97.1	5	2.1	2	0.8
Hygiene of the Skin	234	97.5	5	2.1	1	0.4
The Human Skeleton	229	95.4	5	2.1	6	2.5
Skeletal Muscles	229	95.4	5	2.1	6	2.5
Blood	236	98.4	3	1.2	1	0.4
Heart and Blood Vessels	239	99.6	1	0.4	0	0.0
Blood Circulation	240	100.0	0	0.0	0	0.0
Lymph	158	65.8	32	13.3	50	20.8
Respiratory System	180	75.0	27	11.2	33	13.8
Respiratory Movement	199	82.9	22	9.2	19	7.9
Food	235	97.9	2	0.8	3	1.2
Digestive System	214	89.2	13	5.4	13	5.4
Digestion	220	91.7	9	3.8	11	4.6

Appendix VI (cont.)

Metabolism	237	98.8	2	0.8	1	0.4
Matter Metabolism	204	85.0	21	8.8	15	6.2
Energy Metabolism	204	85.0	21	8.8	15	6.2
Urinary System	208	86.7	15	6.2	17	7.1
Urinary Excretion	232	96.7	3	1.2	5	2.1
Internal System	222	92.5	7	2.9	11	4.6
Nervous System	229	95.4	10	4.2	1	0.4
Spinal Cord	227	94.9	17	7.1	6	2.5
Brain	238	99.2	2	0.8	0	0.0
Higher Nervous Activity	204	85.0	19	7.9	17	7.1
Hygiene of Higher Nervous Activity	121	50.4	62	25.8	57	23.8
Organs of Hearing	204	85.0	24	10.0	12	5.0
Human Development	140	58.3	47	19.6	53	22.1
Reproduction	147	61.2	43	17.9	50	20.8
Conception of Infectious Disease	203	84.6	21	8.8	16	6.7
Prevention of Infectious Disease	240	100.0	0	0.0	0	0.0

Appendix VII

How Much Primary Mathematics is Remembered?

Items	Remembered	Per cent	Impression	Per cent	Forgotten	Per cent
Integer Calculation	269	99.6	1	0.4	0	0.0
Decimal Calculation	268	99.2	2	0.8	0	0.0
Fraction Calculation	263	97.4	5	1.8	2	0.8
Calculation of Area of Rectangle	256	94.8	14	5.2	0	0.0
Calculation of Area of Parallelogram	165	61.1	74	27.4	31	11.5
Calculation of Area of Triangle	193	71.1	49	18.2	29	10.7
Calculation of Area of Trapezoid	83	30.7	132	48.9	55	20.4
Calculation of Area of Circle	127	47.0	78	28.9	65	24.1
Calculation of Area of a Sector	66	24.4	89	33.0	115	42.6
Calculation of Volume of Cuboid	108	40.0	57	21.1	105	38.9
Calculation of Volume of Cylinder	50	18.5	86	31.8	134	49.6
Calculation of Volume of Cone	43	15.9	97	35.9	130	48.1
Drawing a parallelogram from given data	37	13.7	108	40.0	125	46.3
Drawing a broken line from given data	41	15.2	97	35.9	132	48.9
Drawing a sector from given data	37	13.7	97	35.9	136	50.4
Rhyme for reckoning on the Abacus	154	57.0	73	27.0	43	15.9
Addition and Subtraction on the Abacus	176	65.2	78	28.9	16	5.9
Multiplication on the Abacus	155	57.4	76	28.1	39	14.4
Percentage	207	76.7	59	21.8	7	2.6
Proportion	184	68.1	72	26.7	14	5.2
Solving a Problem with an Equation	83	30.7	96	35.6	91	33.7
General Applied Problem	99	36.7	87	32.2	64	23.7

Appendix VIII

How Well Does Primary Science Meet Social Needs?

Topics	Necessary	Per cent	Less Necessary	Per cent	Unnecessary	Per cent
Seasons	121	100.0	0	0.0	0	0.0
Change of Air Temperature	120	99.2	1	0.8	0	0
Reasons for Change of Air Temperature	64	52.9	44	36.4	14	10.7
Relation Between Change of Air Temperature and the life of Mankind	83	68.6	25	20.7	13	10.7
Water	121	100.0	0	0.0	0	0.0
Three States of Water	119	98.3	2	1.7	0	0.0
Archimedes' Principle	61	50.4	46	30.8	14	11.6
Purification of Water	62	51.2	22	18.2	37	30.6
Relation Between Water and Living Things	96	79.3	12	9.9	13	10.7
Geological Action of Water	28	23.1	39	32.2	54	44.6
Cycle of Water	29	24.0	38	31.4	54	44.6
Use of Conservancy	102	84.3	18	14.9	1	0.8
Action of Steam Force	89	73.6	23	19.0	9	7.4
Pollution and Protection of Water	96	79.3	15	12.4	10	8.3
Atmosphere	120	99.2	1	0.8	0	0.0
Geological Action of Wind	17	14.0	42	34.7	62	51.2
Principle of Flying	36	29.8	54	44.6	31	25.6
Composition of Air	78	64.5	26	21.5	17	14.0
Relation Between Air and Living Things	81	66.9	28	23.1	12	9.9
Pollution and Protection of Air	99	81.8	18	14.9	4	3.3
Structure of the Earth	86	71.1	25	20.7	10	8.3
Different Kinds of Rocks	23	19.0	49	40.5	49	40.5
Underground Minerals	64	52.9	37	30.6	20	16.5
Soil and Its Protection	102	84.3	14	11.6	5	4.1
The Moon	121	100.0	0	0.0	0	0.0
Satellites	97	80.2	22	18.2	2	1.6
Revolution and Rotation of the Earth	89	73.6	26	21.5	6	5.0

Appendix VIII (cont.)

The Sun	120	99.2	1	0.8	0	0.0
The Galaxy	76	62.8	32	26.4	13	10.7
Exploring the Galaxy	76	62.8	32	26.4	13	10.7
Flowering Plants	89	73.6	21	17.4	11	9.0
Non-flowering Plants	78	64.5	32	26.4	11	9.0
Life of Flowering Plants	83	68.6	26	21.5	12	9.9
Relation Between Plants and the Environment	77	63.6	28	23.1	16	13.2
Invertebrates	78	64.5	31	25.6	12	9.9
Vertebrates	78	64.5	31	25.6	12	9.9
Life of Animals	62	51.2	47	38.8	12	9.9
Protection of Animals	79	65.3	28	23.2	14	11.6
Movement of Body	112	92.6	6	5.0	3	2.5
Evolution of Living Things	86	71.1	27	22.3	8	6.6
Ecological Balance	83	68.6	29	24.0	9	7.4
Human Beings and Living Things	80	66.1	31	25.6	10	8.3
Mechanical Movement	56	46.3	41	33.9	24	19.8
Force	63	52.1	37	30.6	21	17.4
Frictional Force and Tension	48	39.7	48	39.7	25	20.7
Simple Machines	69	57.0	36	29.8	16	13.2
Energy	72	59.5	38	31.4	11	9.0
Conservation of Energy	72	59.5	38	31.4	11	9.0
Natural Substances	86	71.1	27	1.6	8	6.6